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Revision Carpal Tunnel Surgery: A 10-Year Review of Intraoperative Findings and Outcomes

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Abstract

Purpose—To evaluate intra-operative findings and outcomes of revision carpal tunnel release (CTR) and to identify predictors of pain outcomes.

Methods—A retrospective cohort study was performed of all adult patients undergoing revision CTR between 2001 and 2012. Patients were classified according to whether they presented with persistent, recurrent, or new symptoms. Study groups were compared by baseline characteristics, intra-operative findings, and outcomes (strength, pain). Within each group, changes in postoperative pinch strength, grip strength, and pain from baseline were analyzed. Predictors of postoperative average pain were examined using both multivariable linear regression analyses and univariable logistic regression to calculate odds ratios of worsened/no change in pain.

Results—Revision CTR was performed in 97 extremities (87 patients). Symptoms were classified as persistent in 42, recurrent in 19, and new in 36 hands. The recurrent group demonstrated more diabetes and a longer interval from primary CTR and was less likely to present with pain. Incomplete release of the flexor retinaculum and scarring of the median nerve were common intraoperative findings overall. Nerve injury was more common in the new group. Postoperative pinch strength, grip strength, and pain significantly improved from baseline in all groups, apart from strength measures in the recurrent group. Persistent symptoms and more than 1 prior CTR had higher odds of not changing or worsening postoperative pain. Higher preoperative pain, use of pain medication, and worker's compensation were significant predictors of higher postoperative average pain.

Discussion—Carpal tunnel release may not always be entirely successful. Most patients do improve following revision CTR, but a methodical approach to diagnosis and adherence to safe surgical principles are likely to improve outcomes. Symptom classification, number of prior carpal tunnel releases, baseline pain, pain medications, and worker's compensation status are important predictors of pain outcomes in this population.

Level of Evidence—Therapeutic Level III

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Keywords

carpal; recurrent; revision; secondary; tunnel

Introduction

Carpal tunnel syndrome (CTS) is the most common compression neuropathy of the upper extremity and is extensively studied (1). The surgical management of CTS crosses many disciplines, and can entail extended incision, limited incision, and endoscopic techniques (2–8). Although complications of carpal tunnel surgery are infrequent, recurrence has been reported in 3–20% of cases (9, 10). Patients presenting with unsatisfactory outcomes following primary carpal tunnel release can be a challenge both diagnostically and therapeutically. Our approach to this population entails a thorough history and physical examination to clearly define the affected sensorimotor distribution and to rule out alternate etiologies for ongoing symptoms, such as cervical radiculopathy, brachial plexopathy, systemic peripheral neuropathy, proximal median nerve compression, and other nerve compression syndromes. In this regard, we find provocative tests and tests for nerve irritation, including Tinel's sign and the scratch collapse test (11), to be highly valuable in our diagnostic algorithm.

In 2001, Tung and Mackinnon classified symptomology following primary carpal tunnel release (CTR) into 3 general categories: persistent, recurrent, and new (2). Persistent CTS refers to the persistence of preoperative symptoms following carpal tunnel release with little or no improvement. Of the complications following CTR, persistence is the most common and is often due to incomplete release of the flexor retinaculum or to incorrect diagnosis (2, 12, 13). Recurrent CTS refers to when the primary release was successful in relieving symptoms, but similar symptoms recur after a period of months or years. The pathogenesis of this recurrent phenomenon is not well understood (13). New symptoms are often reported as increased pain or different symptoms immediately following primary CTR. New symptoms are typically a result of nerve injury, which can include the median nerve proper, common digital nerves, palmar cutaneous branch of the median nerve, or the ulnar nerve (2, 12, 13).

Outcomes following revision carpal tunnel surgery are generally found to be worse than primary surgery, with less success in alleviating patient symptoms (14–16). However, most prior outcome studies of secondary CTR have focused on specific surgical techniques, such as the use of biologic or synthetic barriers for median nerve coverage, and have been limited by small sample size and poor application to wide groups of patients (13, 15, 17–32). The objectives of this study were fourfold: 1) to describe the patient population undergoing secondary carpal tunnel surgery in a high-volume tertiary peripheral nerve center; 2) to relate patients' presenting symptoms (persistent/recurrent/new) to intra-operative findings; 3) to evaluate outcomes of revision CTR, including strength and pain measures, and their relationship to symptom classification; and, 4) to identify predictors of postoperative pain following revision surgery.

Patients and Methods

A retrospective cohort study was performed of all patients who underwent revision carpal tunnel release by the senior author (XXX) between January 2001 and May 2012. All patients had their primary CTR performed at an outside hospital. Decision to re-operate was made based on history and physical examination. Electrodiagnostic studies were obtained in all patients for documentation, specifically for severity of compression neuropathy and to assist

with diagnosis in complex cases, but were generally not used for operative decision-making. Patient symptoms were classified as persistent, recurrent, or new as previously described (2). Institutional review board approval and informed consent from all participants were obtained. All clinical, intra-operative, and outcome data were collected from patient charts.

Surgical technique and intra-operative findings

Operative records were reviewed in detail for all patients meeting eligibility criteria. Intra-operative findings at the time of revision carpal tunnel surgery were recorded as well as any additional surgical procedures performed. The senior author's surgical approach to revision carpal tunnel surgery has been described in detail elsewhere (2). In brief, the surgical incision is made longer and more ulnar than the previous scar, and is always extended proximal to the wrist crease. Identifying the median nerve proximal and distal to the region of prior scarring facilitates safe dissection and avoids iatrogenic nerve injury. Entering the carpal tunnel at its ulnar border also allows for identification of normal anatomic landmarks outside of the zone of previous dissection. This often necessitates release of the Guyon canal in order to safely retract the ulnar neurovascular bundle ulnarly and to adequately visualize the hook of the hamate and the intersection of the hypothenar and thenar musculature that marks the distal extent of the carpal tunnel.

After identifying the median nerve proximally and distally, it is followed into the carpal tunnel. The extent of median neurolysis (ranging from external to internal neurolysis) varies by individual case and depends on the amount of dissection required to see normal fascicular architecture (our end-point for neurolysis). Additional procedures, such as nerve grafting, neuroma excision, and proximal decompression of the median nerve are performed as necessary. Early in the study period, hypothenar fat flaps were also performed for median nerve coverage in patients with major pain and hyperalgesia at the wrist. However, the senior author's current approach does not include the use of tissue interposition flaps in revision carpal tunnel surgery.

Demographic and Outcome data

Baseline clinical information extracted from hospital charts included demographics, comorbidities, worker's compensation status, presenting symptoms, unilateral vs. bilateral involvement, symptom classification (persistent/recurrent/new), use of pain medications (opioids, gabapentin/pregabalin, tricyclic antidepressants), technique of primary CTR (open vs. endoscopic), number of prior CTRs, physical examination (2-point discrimination, pinch and grip strength), self-report pain, and electrodiagnostic evaluations. Post-operatively, pinch strength, grip strength, and pain were recorded at each follow-up time point. For patients with bilateral involvement, information was recorded for each hand independently.

Pinch and grip strength were measured using a Jamar dynamometer (Sammons Preston, Bolingbrook, IL). Pain was evaluated using a self-report questionnaire consisting of 3 10cm visual analog scales (VAS) focusing on average level of pain experienced in the past month, worst level of pain experienced over the past week in each extremity, and impact of pain on self-perceived quality of life (added in 2006). Higher values on the respective VAS are indicative of greater average pain, worst pain, or worsened pain-related quality of life.

Statistical analysis

For each involved extremity, patients were classified according to whether symptoms following primary CTR were persistent, recurrent, or new. Descriptive statistics (means, standard deviations, frequencies) were calculated for all variables by subgroup. Differences in baseline characteristics between persistent/recurrent/new groups were analyzed using 1-

way analysis of variance and chi square tests for continuous and categorical data, respectively. Nonparametric tests were used as appropriate.

Differences in pre- and postoperative pinch strength, grip strength, and pain VAS scores within each subgroup were analyzed using the Wilcoxon rank-sum test. Differences in pre- and postoperative outcomes between groups were analyzed using analysis of variance. Where postoperative data were available at multiple time points, the most recent values were used for analysis.

Predictors of worsened average pain outcomes were analyzed in 2 ways. First, univariable logistic regression was performed to determine the odds of worsened or no change in average pain VAS scores associated with pre- and intra-operative variables. Worsened pain was defined as greater than 1cm increase in VAS score postoperatively, and no change was defined as a postoperative VAS within 1cm of baseline pain score. Second, predictors of postoperative average pain were then explored using a backwards, stepwise linear regression analysis. Dependent variables for the multivariable regression analysis were identified *a priori* and included age, sex, use of pain medications (yes/no), worker's compensation status (yes/no), number of prior CTR (1 vs. more than 1), symptom classification (persistent/recurrent/new), and preoperative average pain VAS score. Using the rule of thumb of 10 patients per predictor variable for linear regression analyses, the regression sample size of 76 hands was sufficient for inclusion of these 7 variables (8 degrees of freedom).

P values less than 0.05 were considered statistically significant.

Results

Patients

Revision carpal tunnel surgery was performed in 97 extremities (87 patients). Symptoms were persistent in 42 (43%), recurrent in 19 (20%), and new in 36 hands (37%). The majority of new symptoms were in the median nerve distribution (n=20/36, 56%), including new median nerve pain (n=15), numbness (n=4), and weakness (n=1). New numbness or pain was also observed in the median palmar cutaneous branch (PCB) (n=5, 14%), PCB plus lateral antebrachial cutaneous nerve (n=1, 3%), and ulnar nerve distributions (n=6, 17%). Chronic regional pain syndrome was present in 4 extremities (11%).

Descriptive characteristics by symptom subgroup are shown in Table 1. Patients with recurrent symptoms were significantly more likely to have diabetes and a longer interval from their primary CTR and less likely to present with pain. All other differences between groups were not statistically significant.

Intra-operative findings and procedures

Tables 2 and 3 summarize the intra-operative findings and additional procedures performed at the time of revision surgery. Nerve injury was significantly more frequent in patients presenting with new symptoms ($P<0.001$). Injuries to critical portions of the median and ulnar nerves were reconstructed with autogenous nerve grafts. Noncritical sensory nerves with gaps less than 3cm were reconstructed with nerve allografts or conduits, and median nerve PCB or lateral antebrachial cutaneous nerve injuries were treated by neuroma resection and proximal transposition.

Postoperative complications of these revision surgeries included 1 infection and 1 hematoma, each requiring reoperation. Other secondary procedures performed after the revision CTR included median nerve decompression in the forearm (n=1), proximal transposition of the common digital nerve to the third webspace (n=2) or to the lateral

antebrachial cutaneous nerve (n=2), ulnar nerve transposition (n=3), decompression of the posterior interosseous nerve (n=2), DeQuervain tendonitis release (n=2), trigger finger release (n=1), and insertion of a dorsal column stimulator (n=2).

Outcomes

Figure 1 illustrates differences in pre- versus postoperative outcome measures by study group. Mean post-operative follow-up was 3.5 ± 2.4 , 4.1 ± 3.7 , and 4.7 ± 3.3 months for the persistent, recurrent, and new subgroups, respectively

Significant increases in pinch and grip strength from baseline were observed in the persistent and new groups ($P < 0.05$), but no significant change in strength measures was seen in the recurrent group. Pain VAS scores improved significantly in all 3 subgroups ($P < 0.01$). The recurrent group demonstrated the most substantial improvement in average and worst pain. No significant differences were observed between study groups in pre- or postoperative outcome measures. However, there was a trend toward better pinch and grip strength in the recurrent group at baseline.

Predictors of postoperative average pain

Odds ratios (Table 4)—More than 1 prior CTR and persistent symptoms were associated with significantly higher odds of worsened or no change in postoperative pain. Use of pain medications also trended towards a higher odds of worsened/no change in pain. Recurrent symptoms and nerve injury were significantly associated with lower odds of no change/worsened pain.

Multivariable analyses (Table 5)—When postoperative VAS scores were analyzed as a continuous variable, higher preoperative average pain, use of pain medication, and worker's compensation were significant predictors of higher postoperative average pain.

Discussion

Patients with recurrent CTS demonstrated key clinical differences from those with persistent and new CTS. First, diabetes was more prevalent, which is not surprising considering the known impact of hyperglycemia and microvascular disease on predisposition to nerve compression (33). Second, the recurrent group was more likely to present with numbness and paresthesias, classic CTS symptoms, rather than pain. In effect, pain was a major complaint in a majority of patients undergoing secondary CTR, with 1/4 to 1/3 of patients taking regular medications for neurogenic hand pain. This is in contrast to primary CTS, where numbness rather than pain is the predominant feature (34).

Our intra-operative findings reflect those of previous reports (12, 13, 16). Incomplete release of the flexor retinaculum and scarring of the median nerve to overlying structures were common findings in all groups. Incomplete release has previously been associated with persistent and recurrent symptoms (12, 13, 16, 35), yet incomplete release was also found in the new group in this study. We hypothesize that incomplete release leaving a small focal compression point (versus pressure equally distributed over the length of the carpal tunnel) can lead to new pain or numbness related to focal nerve ischemia. Consistent with existing literature (2, 13), nerve injury was almost exclusively seen in patients presenting with new CTS. Inadvertent transection of the superficial median fascicles, the third common digital nerve, and median nerve PCB were most common, as in the study by Stutz et al (12). While relatively uncommon, inadvertent nerve injury during CTR can be devastatingly life-altering for the patient, and the importance of excellent visualization and a cautious, methodical approach to CTR cannot be overstated. Finally, other sites of median nerve compression

were identified in 37% of extremities. Although prior studies have suggested that undiagnosed pronator syndrome may be a cause for persistent CTS, we caution that secondary compression points causing double crush syndrome should be evaluated in all patients presenting for revision CTR. We have found the scratch collapse test (11) to be particularly valuable in this regard.

While there are a variety of surgical techniques described for revision CTR, including tissue interposition flaps and nerve wrapping (17–32), such procedures were rarely performed in this series. We believe that any wrapping of the median nerve places it at unnecessary risk for iatrogenic compression. Early in the study period, hypothenar fat flaps were performed for nerve coverage in patients with major incisional pain. However, despite other reports (17, 18, 22) we did not find this procedure to be of benefit in alleviating symptoms. To encourage postoperative nerve gliding, we therefore advocate short periods of immobilization (2–3 days) and early, protected range of motion. As such, we rarely perform opponensplasties at the same time as revision CTR. We do, however, have a low threshold to decompress the Guyon canal. While this may not reflect popular practice, the surgical approach of the senior author has evolved in response to complications of CTR seen at our referral center. Indeed, safely entering the carpal tunnel away from previous scarring and away from the median nerve and preserving one's orientation relative to known anatomic landmarks in the context of noteworthy scar and distorted nerve anatomy is of paramount importance in minimizing complications of revision surgery.

Outcomes following revision CTR were generally positive, with all groups demonstrating significant improvements in postoperative pain. Strength also improved significantly in the persistent and new groups, likely owing to decreased pain and increased use of the affected hand. The lack of improvement in strength in the recurrent group is perhaps due to the minimal weakness and less pain in this group at baseline. We did, however, find a trend towards more favorable pain outcomes in the recurrent group. Stang et al similarly noted that patients with recurrent CTS had better outcomes following revision surgery (36). Incomplete release of the flexor retinaculum has also been associated with improved outcomes (36, 37), although this study and Cobb et al failed to find this association (38). Other factors predictive of worse prognosis following revision CTR include ulnar nerve symptoms (38), symptoms exacerbated by activity (37), absence of nocturnal symptoms (37), a positive Phalen test (37), worker's compensation (38), normal electrodiagnostic testing (38), and nerve injury (2, 36). In this study, patients with nerve injury trended towards better pain outcomes, perhaps because nerve injury is an identifiable and treatable etiology for pain. We also found persistent symptoms, more than 1 prior CTR, baseline pain, taking pain medications, and worker's compensation to be important predictors of worse pain outcomes in this population.

This study is limited by its retrospective nature, exclusion of patients treated with conservative measures, and short follow-up. This is an ongoing challenge in tertiary referral centers, where most patients are from out-of-town. Predictors of outcome in revision carpal tunnel surgery are also difficult to compare across studies, owing to the varying outcome measures used, and insufficient power in this study and others to examine all potential outcome predictors. A standard and accepted measure for outcomes in CTS is lacking, but clinically we have found that patient-reported improvements in symptoms (especially pain) is an important determinant of success in revision CTR. In these complicated cases, it is helpful to know from this study that most patients do demonstrate improvements in pain and strength following revision carpal tunnel surgery.

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Figure 1.

Differences in mean pre- and postoperative physical exam and pain scores classified by subgroup. Error bars signify standard deviation. Asterisks indicate statistically significant changes in pre- versus postoperative scores ($P<0.05$)

Table 1

Baseline characteristics of patients undergoing revision CTR by hand and symptom subgroup

	Persistent N=42	Recurrent N=19	New N=36
Age (yrs); mean, SD	53, 15	55, 11	48, 11
Sex – female	25 (60%)	10 (53%)	20 (56%)
Dominant hand	25 (60%)	13 (68%)	23 (64%)
BMI (kg/m²); mean, SD	31.4, 6.3	28.2, 5.6	28.8, 5.6
Co-morbidities			
Smoker	13 (31%)	10 (53%)	17 (47%)
Diabetes mellitus	5 (12%)*	6 (32%)*	2 (6%)*
Hypothyroidism	3 (7%)	1 (5%)	4 (11%)
Distal radius fracture [¶]	6 (14%)	0 (0%)	6 (17%)
Arthritis	13 (31%)	4 (21%)	11 (31%)
Back pain	16 (38%)	6 (32%)	15 (42%)
Neck pain	15 (36%)	5 (26%)	9 (25%)
CRPS	2 (5%)	0 (0%)	5 (14%)
On pain medication[§]	12 (29%)	5 (26%)	14 (39%)
Worker's compensation	15 (36%)	8 (42%)	22 (61%)
Number of prior releases			
1	34 (79%)	17 (89%)	29 (81%)
2	9 (21%)	2 (11%)	7 (19%)
Primary CTR technique			
Open	37 (88%)	14 (74%)	28 (78%)
Mini-open (short scar)	10 (10%)	2 (11%)	5 (14%)
Endoscopic	5 (12%)	5 (26%)	8 (22%)
Interval from primary CTR (mos); mean, SD	29, 41*	128, 84*	31, 43*
Interval from most recent CTR (mos); mean, SD	25, 40*	127, 85*	27, 25*
Presenting symptom:			
Numbness	32 (76%)	14 (74%)	25 (69%)
Paresthesias	17 (41%)	11 (58%)	14 (39%)
Pain	35 (83%)*	10 (53%)*	30 (83%)*
Weakness	10 (24%)	5 (26%)	9 (25%)
2 point discrimination			
Median: > 6mm	11 (26%)	3 (16%)	7 (19%)

	Persistent N=42	Recurrent N=19	New N=36
Ulnar: > 6mm	5 (12%)	2 (11%)	8 (22%)
Normal EMG/NCS	4 (10%)	2 (11%)	0 (0%)

* Difference between groups $P<0.05$

¶ All patients with distal radius fractures in this study were treated with open reduction internal fixation.

§ Patients were classified as taking pain medications if they were on opioids, gabapentin/pregabalin, and/or tricyclic antidepressants for pain in the involved upper extremity.

Table 2

Intraoperative findings during revision carpal tunnel surgery by hand and symptom subgroup

Intraoperative findings	Persistent N=42	Recurrent N=19	New N=36
Short scar from previous open CTR *	10 (10%)	2 (11%)	5 (14%)
Incomplete release of flexor retinaculum	21 (50%)	12 (63%)	14 (39%)
Proximal	8	5	6
Distal	3	6	7
Proximal and distal	9	1	1
Unspecified	1	-	-
Median nerve scarred to overlying structures	40 (95%)	16 (84%)	29 (81%)
To skin	1	3	1
To previous incision	3	-	1
To flexor retinaculum	27	7	18
To flexor retinaculum & skin	2	2	1
To flexor retinaculum & incision	7	3	7
To flexor retinaculum, skin & incision	-	1	1
Nerve injury/transection **	2 (5%)	2 (11%)	19 (53%)
Median nerve - complete	-	-	1
Median nerve – partial	-	2	7
Common digital nerve to third webspace	-	-	3
Palmar cutaneous branch (median)	2	-	6
Ulnar nerve - complete	-	-	1
Ulnar nerve - partial	-	-	1
1 nerve injury	-	-	5 [§]
Compression of palmar cutaneous branch	0 (0%)	0 (0%)	3 (8%)
1 intraoperative finding	20 (48%)	11 (58%)	21 (58%)

* Short scar defined as <3/4 inch for open CTR. This number does not include the endoscopic CTR group, who by definition had short scar(s).

** $P<0.001$

[§] 2 patients had PCB plus lateral antebrachial cutaneous nerve injury, 1 patient had partial median plus PCB injury, and 2 patients had injuries to the second and third common digital nerves.

Table 3

Additional procedures performed at the time of revision carpal tunnel surgery

Additional procedures performed	Persistent N=42	Recurrent N=19	New N=36
Median nerve procedures			
Decompression in proximal forearm	11 (26%)	3 (16%)	7 (19%)
Decompression in distal forearm *	6 (14%)	-	6 (17%)
Neuroma resection & Reconstruction	-	-	6 (17%)
Autogenous MABC nerve graft	-	-	2
Autogenous sural nerve graft	-	-	1
Nerve allograft	-	-	2
Conduit	-	-	1
Neuroma resection & Proximal transposition	2 (5%)	2 (11%)	11 (31%)
Opponensplasty (Camitz)	-	-	2 (6%)
Hypothenar fat flap for nerve coverage	5 (12%)	3 (16%)	14 (39%)
Ulnar nerve procedures			
Decompression at cubital tunnel – primary [§]	6 (14%)	2 (11%)	3 (8%)
Decompression at cubital tunnel – revision [§]	3 (7%)	-	2 (6%)
Decompression at the Guyon canal	28 (67%)	10 (53%)	25 (69%)
Reconstruction	1 (2%)	-	2 (6%)
Autogenous MABC nerve graft	-	-	2
Nerve transfer [¶]	1	-	-
LABC nerve procedures - Proximal transposition	-	-	2 (6%)

MABC = medial antebrachial cutaneous; LABC = lateral antebrachial cutaneous.

* Decompression of the median nerve in the distal forearm was only performed in patients with a history of distal radius fracture.

[§]The senior author's preferred surgical technique for cubital tunnel syndrome is an anterior transmuscular transposition of the ulnar nerve at the elbow.[¶]Supercharge end-to-side transfer of anterior interosseous nerve to deep motor branch ulnar nerve.

Table 4

Odds of worsened/no change^{*} in post-operative average pain VAS scores from baseline associated with pre-operative factors and intra-operative findings

	OR (95% CI)	P value
Age (yrs)	1.02 (0.98, 1.06)	NS
Sex: female vs. male	0.88 (0.32, 2.41)	NS
Dominant hand: yes vs. no	2.03 (0.69, 5.97)	NS
BMI (kg/m²)	1.03 (0.95, 1.11)	NS
Co-morbidities: yes vs. no		
Smoker	0.76 (0.28, 2.04)	NS
Diabetes mellitus	0.58 (0.11, 3.05)	NS
Hypothyroidism	0.28 (0.03, 2.41)	NS
Distal radius fracture	1.10 (0.25, 4.81)	NS
Arthritis	1.02 (0.35, 2.95)	NS
Back pain	0.80 (0.29, 2.21)	NS
Neck pain	0.85 (0.30, 2.43)	NS
CRPS	0.41 (0.05, 3.70)	NS
On pain medication: yes vs. no	2.47 (0.91, 6.71)	0.077
Worker's compensation: yes vs. no	1.01 (0.38, 2.67)	NS
Number of prior releases: 2 vs. 1	4.70 (1.34, 16.46)	0.015
Primary CTR: Endoscopic vs. open	0.60 (0.15, 2.42)	NS
Interval from 1° CTR (mos)	1.00 (0.99, 1.01)	NS
Interval from last CTR (mos)	1.00 (0.99, 1.01)	NS
Presenting symptom:		
Numbness: yes vs. no	0.68 (0.24, 1.88)	NS
Paresthesias: yes vs. no	0.41 (0.15, 1.16)	NS
Pain: yes vs. no	0.44 (0.14, 1.41)	NS
Weakness: yes vs. no	1.73 (0.57, 5.29)	NS
2PD median: >6mm vs. 6mm	2.28 (0.75, 6.94)	NS
2PD ulnar: >6mm vs. 6mm	0.84 (0.23, 3.03)	NS
EMG/NCS: normal vs. abnormal	0.54 (0.06, 5.12)	NS
Symptom classification		
Persistent: yes vs. no	3.43 (1.25, 9.41)	0.017
Recurrent: yes vs. no	0.15 (0.02, 1.19)	0.072

	OR (95% CI)	P value
New: yes vs. no	0.63 (0.23, 1.73)	NS
Pre-operative average pain VAS score	1.00 (0.99, 1.01)	NS
Intraoperative findings: yes vs. no		
Short scar	0.30 (0.06, 1.48)	NS
Scarring to overlying structures	>999 (<0.001, >999)	NS
Incomplete release	0.56 (0.21, 1.49)	NS
Nerve injury	0.29 (0.08, 1.13)	0.074
PCM compression	<0.001 (<0.001, >999)	NS
Follow-up (mos)	0.93 (0.78, 1.09)	NS

* Worsened/no change in average pain VAS scores was defined as <1cm decrease in post-operative VAS scores from baseline. 1cm decrease in VAS score from baseline was considered an improvement.

Table 5

Significant predictors of post-operative average pain VAS scores in exploratory multivariable regression analyses (n=76)

Outcome = “average pain” R²=0.291 (df=3)		Standard error ()	t	P value
Constant	0.518	0.866	0.598	0.552
Pre-operative “average pain”	0.352	0.128	2.751	0.008
Taking pain medication	1.843	0.57	3.231	0.002
Worker’s compensation status	1.221	0.562	2.175	0.033

Sequence of removal of nonsignificant variables in the backwards stepwise regression: sex, age, symptom classification, BMI, and number of prior releases.